REMARKS

In view of the following discussion, the Applicant respectfully submits that none of the presented claims now pending in the application is made obvious under the provisions of 35 U.S.C. §103. Thus the Applicant believes that all of the presented claims are now in allowable form.

In addition, the Applicant's representative would like to thank Examiner Monbleau for kindly taking a substantial amount of time on February 1, 2006 to discuss the merits of the subject invention. The Applicant's representative is aware of the time constraint that is placed on the Examiner and is appreciative of the Examiner's willingness to devote such large quantity of time to discuss the case on the merits.

I. REJECTION OF CLAIMS 1, 3-11 AND 13-17 UNDER 35 U.S.C. §103

The Examiner rejected claims 1, 3-11 and 13-17 under 35 U.S.C. §103(a) as being unpatentable over the Merrill et al. patent (United States Patent on No. 6,841,816, issued January 11, 2005, hereinafter referred to as "Merrill"). In response, the Applicant has amended independent claims 1 and 11, from which claims 3-10 and 13-17 depend, in order to more clearly recite aspects of the present invention.

Merrill teaches a vertical color filter sensor group with non-sensor filter. The sensor group is formed on a substrate (*e.g.*, a semiconductor substrate) and includes at least two vertically stacked, photosensitive sensors. At least one filter is positioned between two of the sensors such that radiation propagated through or reflected from the filter propagates into at least one of the sensors. In some embodiments, the filters are transmissive to radiation in a first wavelength band, but reflect radiation in a second wavelength band. The primary purpose of such a filter positioned between the two sensors is to increase a ratio of relevant light to irrelevant light that is absorbed by the sensor disposed beneath the filter. For example, a "red pass/cyan reflect" filter may be positioned beneath a green sensor and above a red sensor in order to increase the ratio of red to green (and red to blue) light that is absorbed by the red sensor by filtering the red light through to the red sensor and reflecting cyan light back toward the green sensor (*i.e.*, away from the red sensor).

The Examiner's attention is directed to the fact that Merrill fails to disclose or suggest the novel invention of maximizing the electric charge produced in each color sensor of a three-dimensional, vertical stack of color sensors by placing color reflectors between both sensor pairs and between a semiconductor substrate and the stack of color sensors, as positively claimed by the Applicant. Specifically, the Applicant's independent claims 1 and 11, as amended, recite:

> 1. An imaging sensor comprising a plurality of pixels, where each of said pixels comprises;
> a semiconductor substrate;
> a three-dimensional, vertical stack of color sensors on the semiconductor substrate; and
> a plurality of color reflectors, wherein each pair of adjacent color sensors is separated by one of said color reflectors, and wherein the semiconductor substrate is separated from the three-dimensional, vertical stack of color sensors by one of said color reflectors, each of said color reflectors being positioned to maximize an electric charge produced in an associated one of said color sensors after light passes through said associated one of said color sensors for a first time. (Emphasis added)

> 11. An imaging sensor comprising:
> a semiconductor substrate having a plurality of crossing row and column conductors;
> a row decoder for selectively applying potentials to a set of row conductors;
> a column decoder for selectively reading charges on a set of column conductors;
> a pixel matrix comprised of a plurality of pixels, where each of said pixels is located adjacent to one of said crossings of row and column conductors, wherein each pixel comprises:
> a three-dimensional, vertical stack of color sensors on said semiconductor substrate; and
> a plurality of color reflectors, wherein each pair of adjacent color sensors is separated by one of said color reflectors, and wherein the semiconductor substrate is separated from the three-dimensional, vertical stack of color sensors by one of said color reflectors, each of said color reflectors being positioned to maximize an electric charge produced in an associated one of said color sensors after light passes through said associated one of said color sensors for a first time; and

> electrical connectors that electrically connect each color sensor to one of said row conductors and to one of said column conductors. (Emphasis added)

The Applicant's invention is directed to multi-spectral imaging with almost-full fill-factor using 3D pixels. Existing solid-state color imaging systems, which typically perform color imaging using pixel sensor elements and absorptive color filters, are prone to several limitations. For instance, color information obtained from a typical sensor element is less than optimal, because each sensor element takes up only a portion of a pixel's area. Moreover, the amount of light that is received by each sensor element is less than the amount of light impinging upon the associated pixel, because some of the light is filtered away by the absorptive color filters and because the sensor element typically has a less than 100% fill factor.

The Applicant's invention is an imaging device having pixels comprised of three-dimensional stacks of color sensors on semiconductor substrates. Each stack includes a plurality of color sensors and a wavelength sensitive color reflector positioned between each pair of sensors. Another reflector is positioned between the semiconductor substrate and the stack of sensors. In operation, incoming light is partially absorbed by a color sensor and converted to an electric charge. A portion of the unabsorbed light is reflected by the associated reflector and produces and additional electric charge. The remainder of the unabsorbed light transmits through the reflector to the next sensor, where the light is treated in a similar manner by the next sensor and its associated reflector. This process continues until the light reaches the final reflector, positioned directly between the final sensor and the semiconductor substrate. Thus, light effectively passes twice through each sensor: first when the light is incoming, and then again when the light is reflected.

By contrast, Merrill fails to teach or suggest the need to pass light twice through <u>each sensor</u>. Specifically, the sensor taught by Merrill does not include a reflector <u>positioned between the semiconductor substrate and the sensor stack</u> (*i.e.*, such that the electric charge in <u>each sensor</u> in the stack, <u>including the final sensor before the semiconductor substrate</u>, is maximized).

As discussed, the Applicant's imaging device includes reflectors positioned not just between each pair of sensors, but also <u>between the semiconductor substrate and the sensor stack</u>. This improves the absorption of relevant light by <u>each sensor</u> in the stack, <u>including the final sensor before the substrate</u>, because at least a portion of the light that transmits through the sensor is reflected back to the sensor. Merrill, on the other hand, teaches away from such a configuration.

Firstly, Merrill is <u>completely devoid</u> of any explicit teaching relating to the need or desirability for a reflector positioned between the semiconductor substrate and the sensor stack (*i.e.*, between the "red" sensor and the substrate).

Secondly, Merrill goes out of its way to teach partially reflective filters positioned <u>between color sensor pairs</u> (*i.e.*, between the "blue" sensor and the "green" sensor, and between the "green" sensor and the "red" sensor). The lack of teaching relating to a need for a similar reflective filter positioned between a final sensor (*i.e.*, the "red" sensor) and the substrate is therefore all the more telling.

The Applicant submits that the primary purpose of the reflective filters taught by Merrill is to increase a ratio of relevant light to irrelevant light that is absorbed by a sensor disposed <u>beneath a given filter</u> (*i.e.*, the primary purpose is to <u>filter irrelevant wavelengths from incoming light</u>). Although Merrill mentions that light reflected by a given filter has another chance to be absorbed in an associated sensor (*i.e.*, positioned above the reflective filter), this advantage is described in a manner that indicates that it is incidental to the primary advantage achieved by filtering. Thus, the primary objective for including the reflective filters can be achieved <u>without an additional reflective filter positioned between the final sensor and the substrate</u> (since there are no remaining sensors for which the incoming light must be filtered). The Applicant therefore submits that Merrill neither contemplates nor motivates the inclusion of a reflective filter positioned between the substrate and the sensor stack (*i.e.*, between the substrate and the "red" filter).

Merrill thus fails to disclose or suggest the novel invention of <u>separating a semiconductor substrate from a three-dimensional, vertical stack of color sensors by a color reflector</u>, as claimed in Applicant's independent claims 1 and 11. Therefore, the

Applicant submits that independent claims 1 and 11 fully satisfy the requirements of 35 U.S.C. §103 and are patentable thereunder.

Dependent claims 3-10 and 13-17 depend from claims 1 and 11 and recite additional features therefore. As such, and for at least the same reasons set forth above, the Applicant submits that claims 3-10 and 13-17 are not made obvious by the teachings of Merrill. Therefore, the Applicant submits that dependent claims 3-10 and 13-17 also fully satisfy the requirements of 35 U.S.C. §103 and are patentable thereunder.

CONCLUSION

Thus, Applicant submits that none of the claims presently in the application are made obvious under the provisions of 35 U.S.C. §103. Consequently, Applicant believes that all these claims are presently in condition for allowance. Accordingly, both reconsideration of this application and its swift passage to issue are earnestly solicited. If applicable, Applicant also reserves the rights to file one or more continuation applications for any canceled claims in the present application.

If the Examiner believes that there are any unresolved issues requiring maintenance of the final action in any of the claims now pending in the application, it is requested that the Examiner telephone Mr. Kin-Wah Tong at (732) 530-9404 so that appropriate arrangements can be made for resolving such issues as expeditiously as possible.

Respectfully submitted,

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